CLAIMS

1. An electrostatic actuator comprising:

a substrate;

an electrode formed on said substrate;

a plurality of partition parts formed on said electrode;

a vibration plate formed on said partition parts, said vibration plate being deformable by an electrostatic force generated by a voltage applied to said electrode; and

an air gap formed between said plurality of partition parts by etching a part of a sacrifice layer formed between said electrode and said vibration plate,

wherein said partition parts comprise remaining parts of said sacrifice layer after said etching.

2. The electrostatic actuator as claimed in claim 1, wherein said substrate is a silicon substrate.

3. The electrostatic actuator as claimed in claim 1, further comprising dummy electrodes at positions corresponding to said partition parts, said dummy electrodes being electrically separated from said

electrode by separation grooves.

4. The electrostatic actuator as claimed in claim 1, wherein said sacrifice layer is formed of a material selected from a group consisting of polysilicon, amorphous silicon, silicon oxide, aluminum, titanium nitride and polymer.

5. The electrostatic actuator as claimed in claim 1, wherein said electrode is formed of a material selected from a group consisting of polysilicon, aluminum, titanium, titanium nitride, titanium silicide, tungsten, tungsten silicide, molybdenum, molybdenum silicide and ITO.

6. The electrostatic actuator as claimed in claim 3, wherein an insulating layer is formed on said electrode, and said separation grooves are filled with the insulating layer.

7. The electrostatic actuator as claimed in claim 6, wherein a thickness of said insulating layer is equal to or greater than one half of a width of each of said separation grooves.

8. The electrostatic actuator as claimed in claim 1, wherein said sacrifice layer is divided by separation grooves, and an insulating layer is formed on said sacrifice layer so that said separation grooves are filled with said insulating layer.

9. The electrostatic actuator as claimed in claim 8, wherein a thickness of said insulating layer is equal to or greater than one half of a width of each of said separation grooves.

10. The electrostatic actuator as claimed in claim 1, wherein said sacrifice layer is formed of a conductive material, and said remaining parts of said sacrifice layer are electrically connected to one of said substrate, said electrode and said vibration plate so that said remaining parts are at the same potential with said one of said substrate, said electrode and said vibration plate.

11. The electrostatic actuator as claimed in claim 3, wherein said sacrifice layer is formed of a conductive material, and at least one of said remaining parts of said sacrifice layer and said dummy electrodes serve as a part of electric wiring.

12. The electrostatic actuator as claimed in claim 1, further comprising insulating layers on said electrode and a surface of said vibration plate facing said electrode, wherein said sacrificing layer is formed of one of polysilicon and amorphous silicon, and said insulating layers are formed of silicon oxide.

13. The electrostatic actuator as claimed in claim 1, wherein said sacrificing layer is formed of silicon oxide and said electrode is formed of polysilicon.

14. The electrostatic actuator as claimed in claim 1, wherein a through hole is formed in said vibration plate for removing by etching the parts of said sacrifice layer through said through hole so as to form said air gap.

15. The electrostatic actuator as claimed in claim 14, wherein said through hole is located near said partition parts.

16. The electrostatic actuator as claimed in claim 1, wherein said vibration plate has substantially a rectangular shape, and a shorter side of said

vibration plate is equal to or less than 150 μm.

17. The electrostatic actuator as claimed in claim 1, wherein a distance of said air gap measured in a direction perpendicular to a surface of said electrode facing said vibration plate is substantially 0.2 μm to 2.0 μm.

18. The electrostatic actuator as claimed in claim 14, wherein a plurality of said through holes are arranged along a longer side of said vibration plate at an interval equal to or less than a length of the shorter side of said vibration plate.

19. The electrostatic actuator as claimed in claim 1, further comprising:

a through hole formed in said vibration plate for removing the parts of said sacrifice layer through said through hole so as to form said air gap; and

a resin film formed on a surface opposite to a surface facing said electrode,

wherein said through hole is sealed by said resin film of said member.

20. The electrostatic actuator as claimed in

claim 19, wherein a cross-sectional area of said through hole is substantially equal to or greater than 0.19 μm^2 and equal to or less than 10 μm^2.

21. The electrostatic actuator as claimed in claim 19, wherein a thickness of an insulating layer in a periphery of an opening of said through hole is substantially equal to or greater than 0.1 μm.

22. The electrostatic actuator as claimed in claim 19, wherein said resin film has a corrosion resistance with respect to a substance to be brought into contact with said vibration plate.

23. The electrostatic actuator as claimed in claim 19, wherein said resin film is formed of one of a polybenzaoxazole film and a polyimide film.

24. The electrostatic actuator as claimed in claim 14, further comprising a member joined to an upper surface of said vibration plate, wherein said through hole is sealed by a joining surface of said member.

25. The electrostatic actuator as claimed in claim 1, further comprising an insulating layer formed

on a surface of said vibration plate facing said electrode, wherein a thickness of said insulating layer near a center between said partition parts adjacent to each other is larger than a thickness of said insulating layer near said partition parts.

26. The electrostatic actuator as claimed in claim 1, further comprising an insulating layer formed on said electrode, wherein a thickness of said insulating layer near a center between said partition parts adjacent to each other is larger than a thickness of said insulating layer near said partition parts.

27. The electrostatic actuator as claimed in claim 1, wherein a cavity is formed between said electrode and said substrate, and said electrode has a connection through hole connecting said cavity to said air gap.

28. The electrostatic actuator as claimed in claim 27, further comprising insulating layers on both sides of said electrode, wherein a total thickness of said electrode and said insulating layers exceeds a thickness of said vibration plate.

29. A method for manufacturing an electrostatic actuator comprising the steps of:

forming an electrode on a substrate;

forming a sacrifice layer on said electrode;

forming a vibration plate on said sacrifice layer, the vibration plated being deformable by an electrostatic force generated by a voltage applied to said electrode; and

forming an air gap between said electrode and said vibration plate by removing a part of said sacrifice layer by etching so that remaining parts of said sacrifice layer after the etching form partition parts that define the air gap.

30. The method of an electrostatic actuator as claimed in claim 29, wherein said air gap forming step includes etching the part of said sacrifice layer after forming said electrode and said vibration plate.

31. The method of an electrostatic actuator as claimed in claim 29, further comprising a step of forming an insulating layer on said electrode before forming said sacrificing layer,

wherein said air gap forming step includes etching said insulating layer so that a thickness of

said insulating layer near a center between said partition parts adjacent to each other is larger than a thickness of said insulating layer near said partition parts.

32. The method of an electrostatic actuator as claimed in claim 29, further comprising a step of forming an insulating layer on a surface of said vibration plate facing said electrode after forming said sacrificing layer,

wherein said air gap forming step includes etching said insulating layer so that a thickness of said insulating layer near a center between said partition parts adjacent to each other is larger than a thickness of said insulating layer near said partition parts.

33. The method of an electrostatic actuator as claimed in claim 30, further comprising:

a step of forming an insulating layer on said electrode; and

a step of forming an insulating layer on a surface of said vibration plate facing said electrode,

wherein the etching of said sacrifice layer is performed by one of a plasma-etching method using sulfur

hexafluoride (SF_6) or xenon difluoride (XeF_2) and a wet-etching method using tetra-methyl-ammonium-hydroxide (TMAH).

34. The method for manufacturing an electrostatic actuator as claimed in claim 29, further comprising the steps of:

forming a through hole in said vibration plate for removing the part of said sacrifice layer; and

forming a resin film on said vibration plate so as to seal said through hole.

35. The method for manufacturing an electrostatic actuator as claimed in claim 29, wherein said vibration plate forming step includes a step of forming said vibration plate in a rectangular shape having a shorter side equal to or smaller than 150 μm.

36. The method for manufacturing an electrostatic actuator as claimed in claim 29, wherein said vibration plate forming step includes a step of forming a bend-preventing film that prevents said vibration plate from being bent.

37. The method for manufacturing an

electrostatic actuator as claimed in claim 34, wherein said resin film forming step includes a step of changing a surface condition of said vibration plate by exposing a surface of said vibration plate, on which said resin film is to be formed, to a fluorine compound gas including sulfur hexafluoride (SF_6) and xenon difluoride (XeF_2).

38. The method for manufacturing an electrostatic actuator as claimed in claim 34, wherein said resin film forming step includes a step of changing a surface condition of said vibration plate by exposing to plasma a surface of said vibration plate on which said resin film is to be formed.

39. The method for manufacturing an electrostatic actuator as claimed in claim 34, wherein said resin film forming step includes forming the resin film by a material having a corrosion resistance with respect to a liquid to be brought into contact with said vibration plate.

40. The method for manufacturing an electrostatic actuator as claimed in claim 34, wherein said resin film forming step includes forming the resin

film by a spin-coating method.

41. The method for manufacturing an electrostatic actuator as claimed in claim 29, further comprising the steps of:

forming a through hole in said vibration plate for removing the part of said sacrifice layer; and

joining a sealing member to the surface of said vibration plate so as to seal the through hole.

42. A droplet discharging head comprising:

a nozzle for discharging a droplet of a liquid;

a liquid pressurizing chamber connecting with said nozzle and storing the liquid; and

an electrostatic actuator for pressurizing the liquid stored in said liquid pressurizing chamber,

wherein said electrostatic actuator comprises:

a substrate;

an electrode formed on said substrate;

a plurality of partition parts formed on said electrode;

a vibration plate formed on said partition parts, said vibration plate being deformable by an electrostatic force generated by a voltage applied to

said electrode; and

an air gap formed between said plurality of partition parts by etching a part of a sacrifice layer formed between said electrode and said vibration plate,

wherein said partition parts comprise remaining parts of said sacrifice layer after said etching.

43. The droplet discharging head as claimed in claim 42, wherein a plurality of through holes are formed in said vibration plate for removing by etching the parts of said sacrifice layer through said through holes so as to form said air gap, and a flow passage forming member forming said liquid pressurizing chamber seals the through holes of said vibration plate.

44. The droplet discharging head as claimed in claim 42, wherein said through holes are formed near said partition parts.

45. A liquid supply cartridge comprising:

a droplet discharging head for discharging droplets of a liquid; and

a liquid tank integrated with said droplet discharging head for supplying the liquid to said

droplet discharging head,

wherein said droplet discharging head comprises:

a nozzle for discharging the droplets of the liquid;

a liquid pressurizing chamber connecting with said nozzle and storing the liquid; and

an electrostatic actuator for pressurizing the liquid stored in said liquid pressurizing chamber,

wherein said electrostatic actuator comprises:

a substrate;

an electrode formed on said substrate;

a plurality of partition parts formed on said electrode;

a vibration plate formed on said partition parts, said vibration plate being deformable by an electrostatic force generated by a voltage applied to said electrode; and

an air gap formed between said plurality of partition parts by etching a part of a sacrifice layer formed between said electrode and said vibration plate,

wherein said partition parts comprise remaining parts of said sacrifice layer after said etching.

46. An inkjet recording apparatus comprising:

an inkjet head for discharging droplets of ink; and

an ink tank integrated with said inkjet head for supplying the ink to said inkjet head,

wherein said inkjet head comprises:

a nozzle for discharging droplets of the ink;

a liquid pressurizing chamber connecting with said nozzle and storing the ink; and

an electrostatic actuator for pressurizing the ink stored in said liquid pressurizing chamber,

wherein said electrostatic actuator comprises:

a substrate;

an electrode formed on said substrate;

a plurality of partition parts formed on said electrode;

a vibration plate formed on said partition parts, said vibration plate being deformable by an electrostatic force generated by a voltage applied to said electrode; and

an air gap formed between said plurality of partition parts by etching a part of a sacrifice layer formed between said electrode and said vibration plate,

wherein said partition parts comprise remaining parts of said sacrifice layer after said

etching.

47. A liquid jet apparatus comprising:

a droplet discharge head for discharging droplets of a liquid; and

a liquid tank integrated with said droplet discharging head for supplying the liquid to said droplet discharging head,

wherein said droplet discharging head comprises:

a nozzle for discharging the droplets of the liquid;

a liquid pressurizing chamber connecting with said nozzle and storing the liquid; and

an electrostatic actuator for pressurizing the liquid stored in said liquid pressurizing chamber,

wherein said electrostatic actuator comprises:

a substrate;

an electrode formed on said substrate;

a plurality of partition parts formed on said electrode;

a vibration plate formed on said partition parts, said vibration plate being deformable by an electrostatic force generated by a voltage applied to said electrode; and

an air gap formed between said plurality of partition parts by etching a part of a sacrifice layer formed between said electrode and said vibration plate,

wherein said partition parts comprise remaining parts of said sacrifice layer after said etching.

48. A micro pump comprising:

a flow passage through which a liquid flows:

an electrostatic actuator for deforming said flow passage so that the liquid flows in said flow passage,

wherein said electrostatic actuator comprises:

a substrate;

an electrode formed on said substrate;

a plurality of partition parts formed on said electrode;

a vibration plate formed on said partition parts, said vibration plate being deformable by an electrostatic force generated by a voltage applied to said electrode; and

an air gap formed between said plurality of partition parts by etching a part of a sacrifice layer formed between said electrode and said vibration plate,

wherein said partition parts comprise

remaining parts of said sacrifice layer after said etching.

49. An optical device comprising:

a mirror reflecting a light; and

an electrostatic actuator for deforming said mirror,

wherein said electrostatic actuator comprises:

a substrate;

an electrode formed on said substrate;

a plurality of partition parts formed on said electrode;

a vibration plate formed on said partition parts, said vibration plate being deformable by an electrostatic force generated by a voltage applied to said electrode; and

an air gap formed between said plurality of partition parts by etching a part of a sacrifice layer formed between said electrode and said vibration plate,

wherein said partition parts comprise remaining parts of said sacrifice layer after said etching, and said mirror is formed on said vibration plate so that said mirror is deformable by deformation of said vibration plate.